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FROM: G. W. EARLE *GW Earle*

RADIATION INTENSITIES FROM AGED PLUTONIUM OXIDE

SROO requested the plant to investigate capability of storing SRP plutonium as the oxide for periods of one, three and five years. As a portion of this study, the Health Physics Division was requested to determine radiation intensities from aged plutonium oxide and resultant dose rates in storage facilities and during subsequent reprocessing.

SUMMARY

Radiation intensities at one foot from a 2 Kg package of typical plutonium oxide were calculated as shown below:

<u>Age</u>	<u>mR/hr</u>	<u>mrem/hr</u>
One year	80	2.66
Three years	185	2.66
Five years	290	2.66

Radiation intensity at a point five feet above the floor of a typical storage location (Building 235-F downstairs vault) were calculated as shown below (See sketch #1 for dose point and proposed storage array):

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<u>Age</u>	<u>R/hr</u>	<u>mrem/hr</u>
One year	2.73	440
Three years	6.32	440
Five years	9.90	440

During post-storage reprocessing to remove  $^{241}\text{Am}$  and  $^{237}\text{U}$  daughters of  $^{241}\text{Pu}$ , inherent shielding of involved equipment will reduce gamma radiation intensities to insignificant levels.

### RECOMMENDATIONS

It is recommended that packaged plutonium be shielded with a minimum of 1/32 inch thick lead sheeting. This thin shield will reduce the 60 Kev gamma radiation from the  $^{241}\text{Am}$  daughter of  $^{241}\text{Pu}$  to insignificant levels.

### DISCUSSION

Gamma radiation from SRP plutonium is primarily due to the  $^{241}\text{Am}$  daughter of  $^{241}\text{Pu}$  following decay of residual fission products (~ 200 days after final B-Line purification). Minor contributors are the  $^{237}\text{U}$  daughter of  $^{241}\text{Pu}$ , plutonium isotopes and residual fission products. Dose rates from gamma radiation contributors vs time are shown in Graph #1.

Neutron intensities from plutonium oxide are primarily from spontaneous fission of  $^{240}\text{Pu}$ . Minor contributions are from spontaneous fission of  $^{238}\text{Pu}$  plus  $\alpha, n$  reactions with  $^{238}\text{Pu}$ - $^{240}\text{Pu}$ - $^{242}\text{Pu}$  and oxygen. When considering storage of many packages in a storage vault, a neutron multiplication factor of five was used based upon Separations Technology data.

### Basis

Average isotopic concentration -

$^{238}\text{Pu}$  - 93.27%  
 $^{241}\text{Pu}$  - 0.7810%

240, 2 assume  
 $^{240}\text{Pu}$  - 5.9115%  
 $^{242}\text{Pu}$  - 0.03192%

$\text{PuO}_2$  density - 2 g/cm<sup>3</sup>

Container Dimensions - 10.8 cm i.d. x 11.75 cm h

Container shielding - 5.842(10)<sup>-3</sup> cm steel

$\text{PuO}_2$ /container - 2000 g

Pu/container - 1764 g

Isotopic quantities/cm<sup>3</sup>

Basis Contd.

$$^{239}\text{Pu} - 1.6454 \text{ g}$$

$$^{240}\text{Pu} - 1.0428(10)^{-1} \text{ g}$$

$$^{241}\text{Pu} - 1.3777 \text{ g}$$

$$^{242}\text{Pu} - 0.56207 \text{ g}$$

Sp. A and T 1/2 of plutonium isotopes -

$$^{239}\text{Pu} - 6.22(10)^{-8} \text{ Ci/g, } 2.436(10)^4 \text{ y}$$

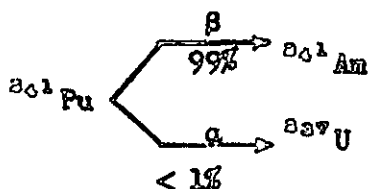
$$^{240}\text{Pu} - 2.30(10)^{-1} \text{ Ci/g, } 6.760(10)^3 \text{ y}$$

$$^{241}\text{Pu} - 1.12(10)^0 \text{ Ci/g, } 1.300(10)^1 \text{ y}$$

$$^{242}\text{Pu} - 4.00(10)^{-3} \text{ Ci/g, } 3.790(10)^5 \text{ y}$$

Ignore Pu decay except for  $^{241}\text{Pu}$

$^{241}\text{Pu}$  daughter activity -



$$^{241}\text{Am} - 3.24 \text{ Ci/g, } 4.58(10)^5 \text{ y}$$

$$^{237}\text{U} - 8.16(10)^0 \text{ Ci/g, } 6.75^d$$

up to 14 years after initial separation,  $\text{Ci } ^{241}\text{Am/g } ^{241}\text{Pu}$

$= 4.28(10)^{-3} t$ , where  $t$  is expressed in days

there are  $4.4(10)^{-6}$   $\alpha$  particles emitted per  $^{241}\text{Am}$  disintegration;

$\text{Ci } ^{237}\text{U/g } ^{241}\text{Pu} = 4.7(10)^{-3} (1 - e^{-1.02(10)^{-3} t})$ , where  $t$  is expressed in days.

Equilibrium will be reached in  $\sim 14$  days.

Fission Product Activity (typical)

$$^{95}\text{Zr-Nb} - 2.30(10)^0 \text{ d/s/g PuO}_2$$

$$^{106}\text{Ru-Rh} - 6.15(10)^0 \text{ d/s/g PuO}_2$$

Neutron data -

Spontaneous fission -

$^{238}\text{Pu}$  -  $3.0(10)^{-2}$  n/s/g

$^{240}\text{Pu}$  -  $1.4(10)^2$  n/s/g

$^{241}\text{Pu}$  - Negligible

$^{242}\text{Pu}$  -  $2.46(10)^2$  n/s/g

$\alpha, n$  reaction with oxygen -

$^{238}\text{Pu}$  -  $4.5(10)^{-1}$  n/s/g

$^{240}\text{Pu}$  -  $1.7(10)^2$  n/s/g

$^{242}\text{Pu}$  - 2.7 n/s/g

Calculations are available in DPSON-92.

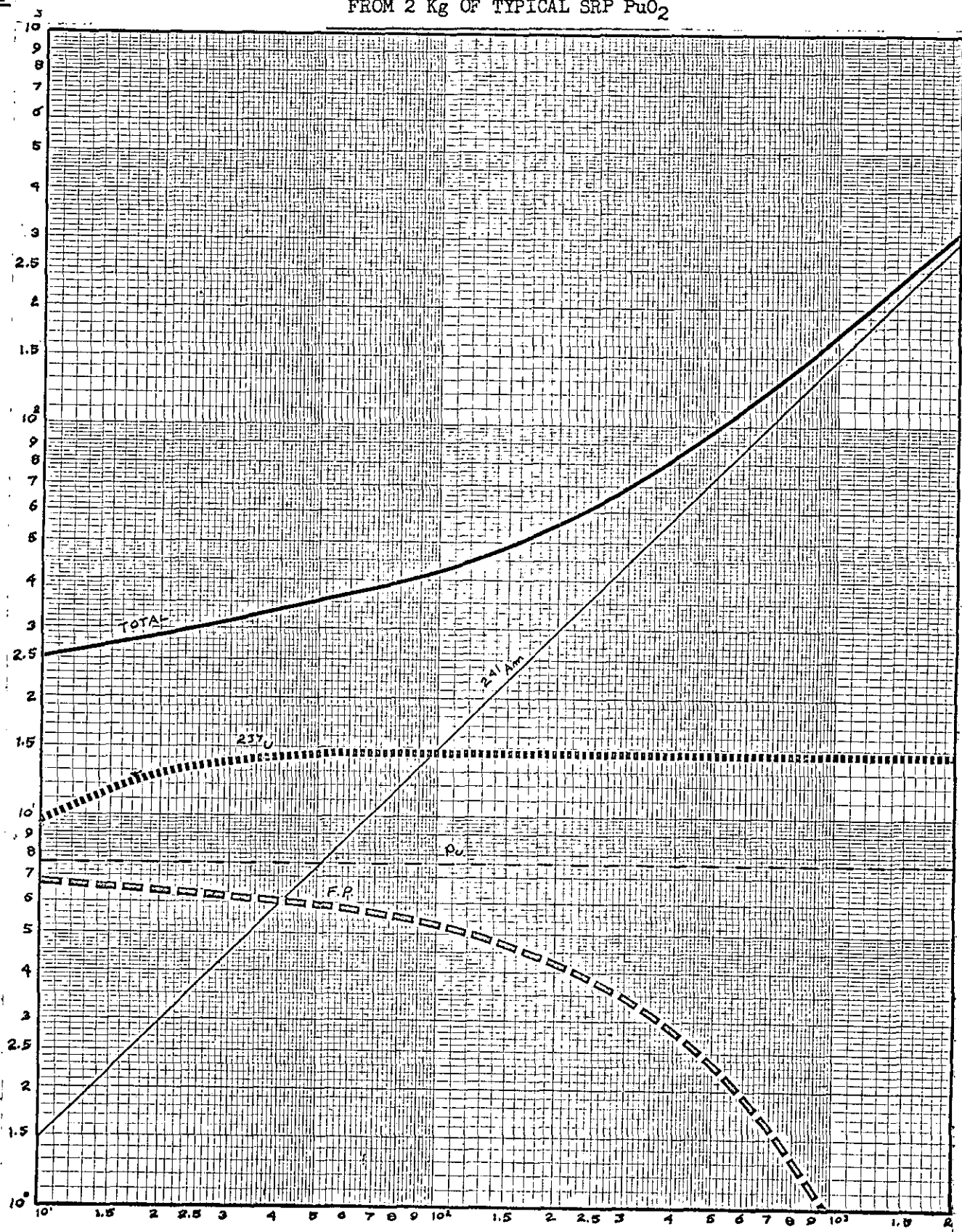
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Attachments

# RADIATION INTENSITY AT ONE FOOT

FROM 2 Kg OF TYPICAL SRP  $\text{PuO}_2$

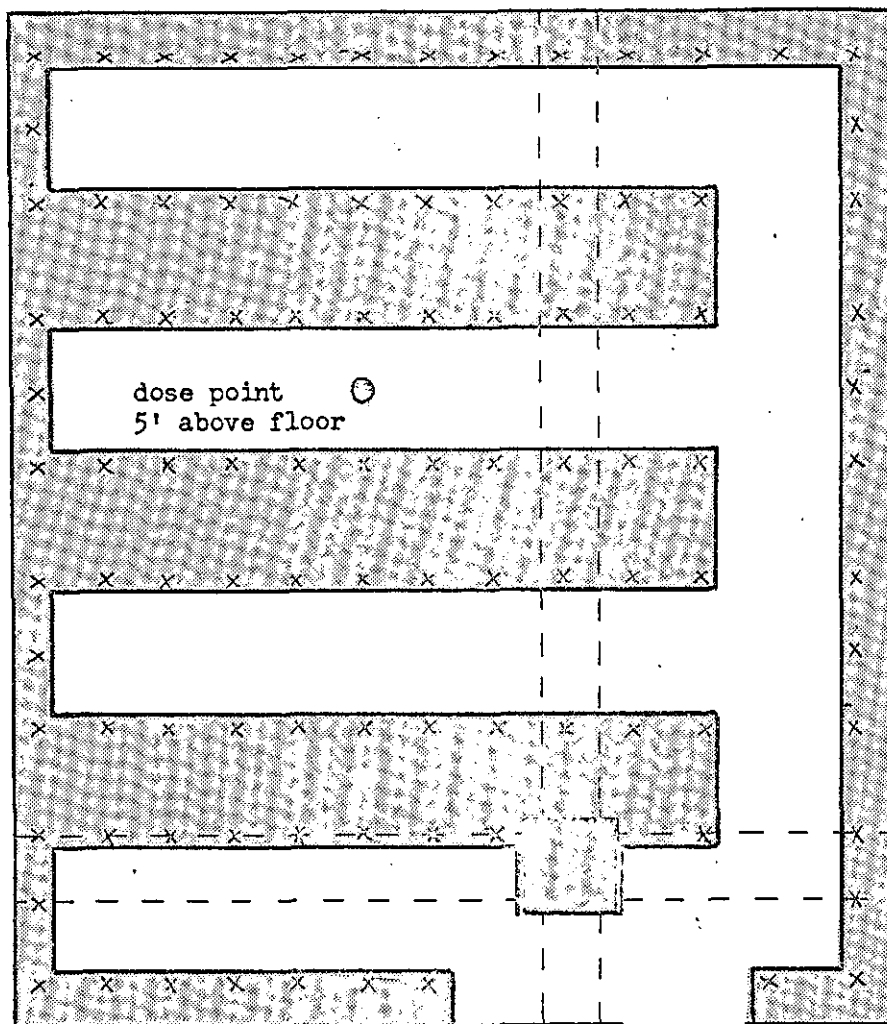
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DAYS SINCE SEPARATION

Graph 1

BUILDING 235-F DOWNSTAIRS VAULT



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ARRAY SPACING:

8 high - 1'-7" centers  
(7 high under beam)

horizontal - 1'-6" centers

SCALE: 1/4" = 1"

x = two 2 Kg packages  
of  $\text{PuO}_2$

Sketch 1